



Reliability of ambulatory walking activity in patients with hematologic malignancies

Knols, R H ; de Bruin, E D ; Aufdemkampe, G ; Uebelhart, D ; Aaronson, N K

Abstract: **OBJECTIVES:** To determine the relative and absolute reliability of the assessment of ambulatory walking activity during 2 consecutive weeks in patients with hematologic malignancies recovering at home from their medical treatment and to compare the physical activity level of hematologic cancer patients after high-dose chemotherapy with healthy subjects. **DESIGN:** Test-retest study of 2 consecutive 7-day recordings using the microprocessor-based step accelerometer 3 (SAM3). **SETTING:** Home and community. **PARTICIPANTS:** Patients (n=23) with hematologic malignancies recovering from high-dose chemotherapy and healthy controls (n=30). **INTERVENTIONS:** Not applicable. **MAIN OUTCOME MEASURES:** The intraclass correlation coefficient (ICC(3,1)) and its 95% confidence interval (CI), SE of measurement procedure and its 95% CI, the smallest detectable difference (SDD), the coefficient of variation (CV), and t tests for the variables total steps and peak activity. **RESULTS:** The day-to-day and week-to-week CVs for walking activity and peak activity were 35.17% and 13.17% and 18.61% and 6.90%, respectively. For relative reliability, the ICCs for 2 consecutive 7-day recordings including the 95% CI for total steps and peak activity were 0.90 (95% CI, 0.75-0.98) and 0.85 (95% CI, 0.66-0.94), respectively. The absolute reliability for total steps and peak activity including the SE of measurement procedure and the 95% CI were 564 (95% CI, +/-1106) and 2.42 steps (95% CI, +/-4.74), respectively, for 2 consecutive 7-day recordings. The week-to-week SDD was 1564 for total steps and 6.70 for peak activity. The 7-day mean for total step activity was 5355 for the patients with hematologic malignancies and 6364 for healthy subjects (P<0.05). **CONCLUSIONS:** The results of this study indicate that there is good relative reliability for the assessment of 2 consecutive 7-day recordings of ambulatory walking activity, and it showed that the SDD derived from this sample may be useful in detecting changes in daily walking activity in hematologic cancer patients who are recovering from intensive medical treatment. The study also documented compromised levels of ambulatory walking activity among hematologic cancer patients recovering from high-dose chemotherapy as compared with healthy controls.

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Reliability of ambulatory walking activity in patients with hematologic malignancies

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Objectives To determine the relative and absolute reliability of the assessment of ambulatory walking activity during 2 consecutive weeks in patients with hematologic malignancies recovering at home from their medical treatment and to compare the physical activity level of hematologic cancer patients after high-dose chemotherapy with healthy subjects. **Design** Test-retest study of 2 consecutive 7-day recordings using the microprocessor based step accelerometer 3 (SAM3). **Setting** Home and community. **Participants** Patients (n=23) with hematologic malignancies recovering from high-dose chemotherapy and healthy controls (n=30). **Interventions** Not applicable. **Main Outcome Measures** The intraclass correlation coefficient (ICC3,1) and its 95% confidence interval (CI), SE of measurement procedure and its 95% CI, the smallest detectable difference (SDD), the coefficient of variation (CV), and *t* tests for the variables total steps and peak activity. **Results** The day-to-day and week-to-week CVs for walking activity and peak activity were 35.17% and 13.17% and 18.61% and 6.90%, respectively. For relative reliability, the ICCs for 2 consecutive 7-day recordings including the 95% CI for total steps and peak activity were 0.90 (95% CI, 0.75 - 0.98) and 0.85 (95% CI, 0.66 - 0.94), respectively. The absolute reliability for total steps and peak activity including the SE of measurement procedure and the 95% CI were 564 (95% CI, \pm 1106) and 2.42 steps (95% CI, \pm 4.74), respectively, for 2 consecutive 7-day recordings. The week-to-week SDD was 1564 for total steps and 6.70 for peak activity. The 7-day mean for total step activity was 5355 for the patients with hematologic malignancies and 6364 for healthy subjects ($P<0.05$). **Conclusions** The results of this study indicate that there is good relative reliability for the assessment of 2 consecutive 7-day recordings of ambulatory walking activity, and it showed that the SDD derived from this sample may be useful in detecting changes in daily walking activity in hematologic cancer patients who are recovering from intensive medical treatment. The study also documented compromised levels of ambulatory walking activity among hematologic cancer patients recovering from high-dose chemotherapy as compared with healthy controls. **Key words** Hematologic neoplasms; Physical activity; Rehabilitation; Technology assessment; Walking.

Introduction

The intensive medical treatment of patients with hematologic malignancies [1-7] is associated with numerous long-term adverse effects, including anemia, fatigue, and reduced physical exercise capacity. [8] Fatigue may compromise general activity, work, enjoyment of life, mood, walking, and relationships with others even for a length of time after medical treatment [9-11] is completed.

It has been shown that patients with hematologic malignancies may benefit from physical exercise programs in terms of maintenance or even improvement in fatigue, physical activity, and fitness levels. [12-14] A major component of daily physical activity and the most common form of exercise is walking. [15] Walking is self regulated in intensity, duration, and frequency and can be an important indicator of a person's health and fitness status.[16] The improvement of functional status is a primary goal in the rehabilitation of cancer patients. [17,18] It is thus important to be able to document quantitatively the walking activity of patients who are recovering from intensive medical treatment. An understanding of the quantity (or lack) of walking activity seems particularly important in addressing the needs of cancer patients who are recovering from intensive medical treatment.

Daily walking activity can be assessed by means of self-report diaries, questionnaires, or objective performance indicators. Self-report measures of walking activity have been reported to be imprecise compared with objective measures. [19,20] Relatively new techniques allowing unobtrusive long-term activity monitoring with the use of pedometers and microprocessor-based accelerometer recorders may provide a clearer view of how much an individual actually walks in his/her own surroundings. [21] However, the major limitations of many pedometers are their accuracy and reliability [21,22] because they are worn at the waist and thus are sensitive to vertical movement. Therefore, the response may be affected by position, mode of the pedometer attachment, movement style, and walking speed of the individual being monitored. [21,22] Microprocessor-based accelerometers are developed to overcome the limitations of waist-attached devices because settings can be adapted according to height, cadence, and the walking style of the subject. [22]

The accuracy of these devices has consistently been reported to be above 98%. [23] Most studies of the test-retest reliability of walking activity have reported only relative reliability, such as the ICCs (varying from 0.84 to 0.97). [19-21,23-28] These statistics indicate the degree of association between 2 or more measures, [29] but they do not provide clinical guidance for assessing real changes. [30,31] Absolute reliability reflects the magnitude of the differences between 2 measures. [32] Examples of these statistics are the SE of measurement procedure and the SDD. [33,34] to be clinically useful, an assessment procedure must have a small measurement error to detect a real change. A test-retest difference in a patient with a value smaller than the SE of measurement is likely to be the result of measurement noise and is unlikely to be detected reliably in practice; a difference greater than the smallest real difference is highly likely (with 95% confidence) to be a real difference. [35] To date, there is no empiric evidence to guide the clinical assessment of real changes in long-term ambulatory walking activity in

hematologic cancer patients who are recovering from intensive medical treatment in their home environment.

Additionally, to date, no study has attempted to quantitatively document the long-term, ambulatory walking activity of hematologic cancer patients after treatment compared with the ambulatory walking activity of healthy subjects. Among healthy individuals, 10,000 steps daily has been estimated to be of value in maintaining desired health benefits. [36] However, preliminary evidence suggests that a goal of 10,000 steps daily may not be sustainable for some groups, including older adults and those living with chronic diseases. [28,36] This finding is supported by the results of a recently published meta-analysis by Bohannon [37] that provided an estimate of the number of daily steps taken by adults. The results of this meta-analysis suggested that the general number of daily steps taken was less than the recommended 10,000 steps a day and that walking activity was especially low in adults 65 years of age or older. In 1 study, [21] the mean 7-day step counts of healthy subjects (6929 steps; range, 4347–10,002 steps) was significantly greater ($P<0.001$) than that of patients with multiple sclerosis (2985 steps; range, 689 - 5340 steps), Parkinson disease (3818 steps; range, 1611–5391 steps), or muscular disorders (3003 steps; range, 716 - 5302 steps). The purpose of this study was to determine the relative and absolute reliability of the assessment of ambulatory walking activity during 2 consecutive weeks in patients with hematologic malignancies recovering at home from their medical treatment and to compare the physical activity level of hematologic cancer patients after high-dose chemotherapy to that of healthy subjects.

Methods

Participants

Patients with a diagnosis of hematologic cancer who had completed treatment with high-dose chemotherapy were selected to participate in the study from the Departments of Oncology and Hematology of the University Hospital Zurich. Patients were excluded from the study if they were experiencing the direct side effects of high-dose chemotherapy (eg, fever, hemoglobin level $<10\text{g/dL}$, emesis, dyspnea, ≤ 36 of 52 points on the FACT-F subscale [38]) in case of gait abnormalities, known impairment of the lower limbs, severe GVHD except for grade 1 not requiring treatment, painful joints, instable osteolyses of the vertebrae, chronic low back pain, lesions of the central or peripheral nervous system, uncontrolled cardiovascular disease, thyroid disease, or diabetes. The patients' walking activity levels were compared with those of 30 subjects without known physical impairments, injuries, or other health-related conditions that hampered walking activity. An inverse correlation has been reported between walking activity, higher BMI, [39] and increased age. [40] Therefore, the healthy subjects were matched for age (years ± 5), sex, and BMI (BMI $\pm 3\text{kg/m}^2$) (table 1) with the patients. The healthy subjects were recruited, at random, from the hospital's employees, including laboratory assistants (n=6), nurses (n=5), physical therapists (n=5), administrative personnel (n=6), physicians (n=1), researchers (n=4), dieticians (n=1), and technicians (n=2). All participants provided written informed

consent. The study was approved by the Ethic Commission of the Canton of Zurich.

Descriptive measures

Height was assessed to the nearest 0.5cm with a wall fixed tape measure and weight to the nearest 0.5kg (SECA weighting machine, Model 791a). Hemoglobin values (g/dL) were determined at the time of an outpatient visit, and self-reported fatigue was assessed with the German language version of the 13-item FACT-F Version 4. [41] This scale includes items relating to both the symptoms and consequences of fatigue and has test-retest reliability ($r=0.90$). [41] Hemoglobin values and self-reported fatigue were measured because both factors (ie, low hemoglobin levels and high fatigue levels) can have adverse effects on physical performance over time. [42]

Step activity monitoring

Step activity levels were assessed with the SAM3.^b The SAM3 measures 75 x 50 x 20mm and weighs approximately 38g. Settings of the SAM3 can be adapted according to the height, cadence, and walking style of the individual. [16] The SAM3 does not allow adjustment and does not require maintenance by the user. The SAM3 is worn on the right lateral or the left medial malleolus. It is contoured to fit comfortably against the leg (figure 1). An elastic attachment strap ensures that the monitor remains securely attached to the ankle without irritating the skin. The SAM3 continuously records the number of steps per time interval. The device is programmed and downloaded onto a host computer via a universal serial bus docking station. Programming and downloading are performed with the StepWatch Analysis Software.^b Information that was routinely recorded in the standard programming mode included the following individual gait characteristics: cadence, speed, the total length of time of the data collection (7 days), and individual identifying information. The device was calibrated by programming estimated values for walking cadence and speed based on the subject's height (patient's or healthy subject's) into the computer before providing the SAM3 to the subject. The subject was then instructed to walk at a normal preferred speed for 20m. The steps of the right leg were counted manually by an observer and compared with those of the SAM3. This procedure was repeated if there was a difference of 2 steps or more between the manual count and that of the step watch monitor. If the manual counting was lower than that of the step monitor, the programmer decreased the value of the cadence of the SAM3. If the manual count remained too high, the sensitivity of the SAM3 was decreased by the programmer. [16]

Recording procedures of the SAM3

Patients and healthy controls were instructed to wear the SAM3 for 7 consecutive days, excluding sleep time. Activity monitoring over a 7-day period has previously been found to result in reliable and representative measures of an individual's movements on a day-to-day basis. [21] All participants were instructed to leave the SAM3 on the ankle if they had to rest or lay down during the day and to perform their daily activities as usual. After 7 days, the participants returned to the hospital, where the data were

downloaded into a database. For patients, this procedure was repeated for a second consecutive 7-day period. When returning the step monitor, we asked the patients if they changed their walking behavior because of health related factors during the 2-week recording time. The walking activity of healthy controls was measured for the initial consecutive 7-day period only.

SAM3 parameters

The parameters assessed by the SAM3 for this study were (1) total steps a day and (2) the peak activity index (the maximum number of steps recorded per time interval for each day).

Statistical analyses

Normality of the data was tested with the Kolmogorov-Smirnov test. [43] Data were analyzed by using the ICC3.1, with 95% CI. [29] An ICC greater than 0.75 was defined as high reliability. [29]

The SE of measurement procedure was calculated from the average known SD and the relative reliability coefficient (r) of the measurement procedure used for our sample: SE of measurement procedure = $SD(\sqrt{1-r})$. [29,34,44,45] The corresponding 95% CI, in which the true score (drawn from the normally distributed population) is expected, was $\pm 1.96 \times$ SE of measurement procedure. [46-48] The broader the limits of the 95% CI, the less confident the estimation of the true score and, as a consequence, the less confident the detection of the real change because of intervention. [45] This knowledge about the SE of measurement procedure is necessary before one can say that such a change has occurred. [46,49] Moreover, when analyzing a difference between 2 consecutive observations, one must consider the SE of measurement procedure of the observed score for both the first week of walking activity (SE of measurement procedure_[first week]) and the second-week (SE of measurement procedure_[second week]) observations. The SDD is known as the measure of statistically significant change between 2 independently obtained measurements. Given a probability value of alpha equal to 0.05 as indication for statistical significance, the SDD is estimated as $1.96 \times (\text{SE of measurement procedure}_{[\text{first week}]}^2 + \text{SE of measurement procedure}_{[\text{second week}]}^2)^{1/2}$. [31] Assuming that the SE of measurement procedure of the observed score of the first and second observations is equal, the SDD is $1.96 \times \sqrt{2} \times$ SE of measurement procedure. For a statistically significant change between 2 separate observations to be detected, this change must be at least the SDD of the measurement procedure. [34]

We determined CV ($SD/\text{mean} \times 100\%$) to examine the individual day-to-day and week-to-week within-subject variability for walking activity (table 2) in hematologic cancer patients. [29] Differences between patients' means for total steps and peak activity were calculated with a paired Student t test to quantify the systematic error (also known as bias) of the step activity monitor. Differences between the patients' and the healthy participants' means for total steps and peak activity were determined with an independent sample t test. [29] All statistical analyses were performed by using SPSS 12.0.1 for Windows^c and Excel 2003 for Windows.^d

Results

Forty-nine adult patients with a diagnosis of hematologic cancer who had completed treatment with high-dose chemotherapy were selected. Five patients were excluded because of low hemoglobin values and/or severe fatigue, and 14 patients were not interested in participating. Specifically, the study sample (n=30) consisted of 14 leukemia patients treated with induction chemotherapy after peripheral blood stem cell transplantation, 11 non-Hodgkin lymphoma patients treated with high-dose chemotherapy alone (n=10) or high-dose chemotherapy after autologous stem cell transplantation (n=1), and 4 multiple myeloma/plasmacytoma patients treated with high-dose chemotherapy alone (n=3) or high-dose chemotherapy after 2 cycles of autologous stem cell transplantation (n=1). All patients participating were in a physically stable condition. Seven of the 30 patients (23%) did not wear the SAM3 consistently during the 7-day period (during waking hours) and were, for that reason, excluded from the analyses. None of the patients reported change in walking behavior because of health-related factors. Thus, the final analysis was performed in 23 patients (12 women/11 men) (see [table 1](#)). The accuracy of the SAM3 was 98% in this study based on a comparison of the number of steps counted by the SAM3 with the observed steps after the cadence had been identified. All results of the step activity measurements and the difference for step activity measurements between week 1 and week 2 were normally distributed.

The ICCs including the 95% CI for total steps and peak activity were 0.90 (95% CI, 0.75 - 0.98) and 0.85 (95% CI, 0.66 - 0.94), respectively. The absolute reliability for total steps and peak activity expressed as the SE of measurement procedure including the 95% CI and the SDD was 564 (95% \pm 1106) and 2.42 (95% CI \pm 4.74), respectively. The SDD was 1564 for total steps and 6.7 for peak activity. The 7-day measurement period (week 1) revealed a day-to-day variability for total steps in hematologic cancer patients as follows: a range of 14,903 (minimum 1008, maximum 15,911), a mean \pm SD of 5355 \pm 2678. The day-to-day and week-to-week mean CV for step counts was 35.17% and 13.23%, respectively (see [table 2](#)). The day-to-day and week-to-week mean CV for peak activity was 18.61% and 6.90%, respectively. There were no significant changes for the total steps and peak activity parameters ([table 3](#)) or were there significant changes for the patient group in hemoglobin values or self-reported fatigue between weeks 1 and 2. The patient group yielded significantly lower mean values for the parameters “total steps” and “peak activity index” than the healthy comparison group ([table 4](#)).

Discussion

This is the first study that provides clinical guidance for the assessment of real changes in long-term day-to-day walking in patients with hematologic malignancies after medical treatment. We have used the ICC (with accompanying 95% CI) and the CV to estimate relative reliability and the SE of measurement procedure (with accompanying 95% CI) and the SDD to estimate measurement error. To be of practical use, the results should be interpreted as follows: the measurements exhibited good relative reliability with an ICC value of 0.9 (95% CI, 0.75 - 0.98), and a CV of 13.23% for the variable total steps.

For the variable peak activity, we estimated an ICC of 0.85 (95% CI, 0.66 - 0.94) and a CV of 6.9%. Although patients reported that they did not change their walking behavior because of changes in health status or symptom burden during the 2-week assessment period, the absolute reliability or measurement error of this parameter is affected by the relatively large variance statistics of the measurements total steps week 1 and week 2, which were 3,719,690 and 2,695,540, respectively (calculated as the square of the SD week 1 [1928.65] and week 2 [1641.81]). The variance statistics of the variable peak activity were 44.89 for week 1 and 42.25 for week 2. When taking the measurement error into account (SE of the measure procedure = 564 for total steps, 2.42 for peak activity), an SDD greater than 1564 total steps (or 6.7 for peak activity) between 2 consecutive 7-day measures should be interpreted as the real change in patients' total steps daily activity. It is reasonable to assume that a significant increase in both variables after, for example, participation in a moderate walking exercise program can be measured with the SAM3. Conversely, however, it would not be possible to detect a real change in daily total step activity or peak activity if the measurement error is larger than the improvement or deterioration in the walking activity of the patient.

Although the SAM3 is a lightweight and unobtrusive device, it is remarkable that 23% of the patients did not comply with wearing the step monitor consistently during the 2 consecutive weeks. To gather representative data, clinicians and researchers should emphasize the importance of the measurement protocol to the participant when wearing a step monitor device. However, the original data for total step activity in 30 patients with hematologic malignancies yielded an equal reliability result for the ICC (0.90). The SDD was 2126. The variance statistics for week 1 and week 2 in 30 patients were 3,342,063 and 3,117,484, respectively. The ICC for peak activity in the original 30 patients was 0.88 and the SDD 8.98. The variance statistic for week 1 and week 2 in 30 patients was 49.28. For the correctness of analysis, we chose to present the data of the 23 complying patients. We compared the total daily ambulatory step activity in patients with hematologic malignancies with those of age-, sex-, and BMI-matched healthy participants. The healthy subjects performed significantly more total daily steps and also had a higher peak activity index, which indicated that the healthy subjects walked with an overall higher intensity than the cancer patients (see table 4). With the improvement of prognosis in hematologic malignancies, walking activity may become an important component in continuing care programs (eg, for physical activity programs that emphasize walking activity and that also consider the intensity of the performed steps as important). Therefore, the amount of steps a day and the peak activity index both appear to be of particular relevance in the case of patients with hematologic cancer who are recovering from systemic treatment because they seem especially suited as outcome parameters for intervention studies.

The findings of our cross-sectional investigation with regard to daily walking activity are supported by several earlier studies. Keats et al. [50] reported that physical activity significantly declined in adolescents who were treated for leukemia and did not return to pretreatment levels after the completion of treatment. Florin et al. [51] reported that long-term survivors of childhood leukemia were less likely to meet physical activity recommendations

and that lowered levels of physical activity increase the risk of cardiovascular disease, osteoporosis, and all-cause mortality. Thus, the long-term implications of a reduction in physical activity, including daily walking activity, may be far reaching for patients with hematologic malignancies. However, longitudinal studies are needed to document the changes in physical activity level in this population of patients.

Our reliability results are similar to those observed in other studies. A test-retest coefficient of 0.97 was observed in 1 study [19] in which the stride counts were counted during a 6-minute walking test. Resnick et al. [24] found an ICC value of 0.84 in a test-retest design when comparing 1-minute walks in elderly adults. Haeuber et al. [25] reported a reliability of 0.96 when stride counts were assessed in a 2- x 24-hour test-retest situation. Finally, Busse et al. [21] reported an ICC of 0.86 and 0.89 in neurologic patients and healthy persons, respectively, in a 2- x 7-day test-retest design in which daily steps were counted. In this study, the day-to-day variability in both healthy individuals and those with neurologic impairment was relatively high as reflected by the CV. [21] The average CV for day-to-day step counts in healthy subjects was 28%, and, in week measures in healthy subjects was 8.8%, and, in neurologic patients, it was 12%. [21] The healthy subjects (mean age, 47y) in our study walked 6363 steps during a consecutive 7-day period. This performance is comparable with the study of Busse et al, [21] in which healthy subjects (mean age, 43y) were reported to walk 6520 steps daily. On the other hand, a meta-analysis of Bohannon [37] provided a daily step count average of 9448 steps (95% CI, 8899 - 9996) taken by healthy adults. The average daily step count performance was divided into 2 groups: subjects younger than 65 years of age who performed 9797 (95% CI, 9216 - 10,377) steps daily and adults over 65 years of age who performed on average 6565 (95% CI, 4897 - 8233) daily steps. As a result, the participating hematologic patients and healthy subjects in our study would be placed in the low active (5000 - 7499 steps/day) category for walking activity [36,37] together with the adults over 65 years of age from the meta-analysis of Bohannon. [37]

We would like to note that our results should be interpreted with some caution. First, measures of unconstrained walking activity directly assess the real-life behavior of the study participants who are facing challenges when walking at home or in the community. [28] During the measurements, external conditions such as weather, [52] suitability of walking activities, or mediators of walking activities such as self-efficacy, social support, or decisional balance [53] and the health condition of the patients may influence the variation observed in walking activity. However, in test situations such as ours, it is possible that the participants, both the cancer patients and the healthy controls, are motivated to perform more walking activity, despite explicit instructions to perform their daily activities as usual and not to perform extra physical activity. Yet, it might also be possible that the participating patients in our study were healthier than other hematologic cancer patients at this stage of their recovery. The main reason for 11 patients not to participate was that they felt too fatigued or too weak. To more fully investigate the multiple sources of potential error in assessing daily walking activity, future work should address a broader set of reproducibility indicators. In line with the generalizability theory, multiple sources of measurement error in walking

activity to be evaluated include whether patients consistently wear the SAM3 (ie, adherence), the between- and within subject variation in day-to-day walking behavior as a function of the number of hours the SAM3 was worn, evidence that the time periods in which walking activity was measured were typical, and the possible effect of health-related factors such as fatigue, infection, and so on on day-to-day walking activity. Using this generalizability approach, reproducibility can be assessed and tailored to the intended applications of the SAM3 in cancer patients. [54]

Second, the point in time at which the patient assessments took place varied considerably (see table 1), and, therefore, some patients may have had the possibility to recover more from the side effects of high-dose chemotherapy than others. This may have influenced the variation observed in the day to-day walking activity. However, there are several reasons why we believe that the chosen sample of hematologic cancer patients after medical treatment was adequate. Our participants were recruited on average 5 months after medical treatment. None of the patients were in the acute phase or experienced the direct side effects of medical treatment. Furthermore, the haemoglobin values and the self-reported symptoms of fatigue did not change significantly over the measurement period and were therefore indicative for a stable physical condition. Nevertheless, one cannot rule out the possibility of a changing physical health status during the 2-week period in which the patients were observed.

Third, the cancer patients in our study were compared with a relatively select sample of healthy participants working in a university hospital setting. As compared with the meta-analyses of Bohannon, [37] other results might have emerged if the comparison had been made with individuals without known physical impairments, injuries, or health-related conditions that would influence walking behavior working in a wider range of settings, including individuals who were either not working or had other societal functions (eg, students, homemakers, and so on). Despite these caveats, we believe that our study provides useful first data regarding the relative reliability of and measurement error associated with walking activity as measured with the SAM3 when used with hematologic cancer patients and documents the sustained deficit in walking activity levels experienced by these patients when compared with age- and sex-matched controls.

Conclusions

This study represents an ongoing process toward developing accurate and reliable tools to describe the individual walking performance in the patients' own environment. The results of this study indicate that there is good relative reliability for the assessment of 2 consecutive 7-day ambulatory walking activity in hematologic cancer patients. This study showed that the SDD derived from this sample may be useful in detecting changes in daily walking activity in hematologic cancer patients who are recovering from intensive medical treatment. The study also documented compromised levels of ambulatory walking activity among hematologic cancer patients recovering from high-dose chemotherapy as compared with healthy controls.

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Suppliers

- a. Hess Medizintechnik AG, Grabenstrasse 2, 8865 Bilten, Switzerland.
- b. Cymatech Corp, 8515 35th Ave NE, Ste C, Seattle, WA 98115.
- c. SPSS Inc. (Switzerland), Schneckemannstrasse 25 8044 Zurich, Switzerland.
- d. Microsoft Inc. (Switzerland), Richtistrasse 3, 8304 Wallisellen (Zurich), Switzerland.

Abbreviations: BMI; body mass index, CI; confidence interval, CV; coefficient of variation, FACT-F; Functional Assessment of Cancer Therapy–Fatigue, GVHD; graft-versus-host disease, ICC; intraclass correlation coefficient, SDD; smallest detectable difference, SAM3; StepWatch Activity Monitor.



Figure 1: The StepWatch Activity Monitor 3 (SAM3[®], Cymatech Corporation, Seattle, WA, USA) is contoured to fit comfortably against the leg. An elastic attachment strap ensures that the monitor remains securely attached to the ankle without irritating the skin.

Table 1. Descriptive measures			
	Patients with hematological malignancies (n=23)	Healthy Participants (n=30)	p-value
Mean Age (sd)	47.83 (14.57)	46.20 (11.83)	.656
Mean Height in cm (sd)	173.35 (9.59)	173.47 (9.09)	.963
Mean Weight in kg (sd)	77.95 (12.90)	72.15 (17.03)	.377
Mean BMI in kg/m ² (sd)	25.08 (3.39)	23.80 (4.01)	.225
Mean time (days) (sd) since medical treatment	142.65 (68.74)	n.a.	n.a.
Fatigue FACT-AN/F (sd)	40.17 (8.28)	n.a.	n.a.
Hemoglobin (g/dl) (sd)	12.25 (1.53)	n.a.	n.a.
Mean values for patients with hematological malignancies and healthy subjects			

Table 2. Day-to-day and week-to-week step counts within hematological patients (n=23)

Step count								7 day mean step count		Day-to-day step count		Week-to-week mean step count		
Patient	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day7	Wk 1	Wk 2	SD	CV %	Mean	SD	CV %
1	3191	4683	5521	2724	7073	5537	6574	5043	4125	1626.58	32,25	4584	649.43	14,17
2	2105	5470	3546	4907	3673	4771	3582	4008	3257	1129.63	28,19	3632	530.73	14,61
3	5317	5142	4055	5506	4737	8161	5201	5446	4653	1289.80	23,69	5049	560.23	11,09
4	1766	6958	3492	4770	4582	4176	4439	4312	3599	1553.12	36,02	3956	503.86	12,74
5	1467	2100	3386	7791	7579	8677	5175	5168	6224	2923.80	56,58	5696	746.60	13,11
6	4519	5284	5742	4853	2916	4172	4106	4513	3746	917.68	20,33	4130	542.25	13,13
7	3598	15911	12074	13799	9845	9125	12282	10948	9484	3965.88	36,23	10216	1034.70	10,13
8	4529	4212	7398	6272	5959	3764	8101	5748	6644	1651.25	28,73	6196	633.87	10,23
9	5616	10566	9350	8588	5508	4130	7150	7273	4699	2332.43	32,07	5986	1819.69	30,40
10	2038	6052	4786	3768	5090	4023	4979	4391	5583	1278.64	29,12	4987	843.17	16,91
11	4406	4435	3821	4590	3039	7312	6839	4920	4981	1568.36	31,88	4951	42.93	0,87
12	3345	6378	4737	6468	4396	2255	7531	5016	4744	1878.22	37,45	4880	192.23	3,94
13	2675	2613	5033	4673	1403	8206	1822	3775	3310	2381.30	63,08	3543	328.60	9,28
14	1167	5076	7599	2549	5766	4203	5641	4572	3048	2152.82	47,09	3810	1077.02	28,27
15	5351	5998	8396	9665	8348	9771	7757	7898	5581	1693.03	21,44	6739	1638.67	24,32
16	5785	6223	8487	11949	7867	8746	9381	8348	7952	2062.68	24,71	8150	280.01	3,44
17	2529	7137	11475	5427	6915	4378	7410	6467	5583	2815.80	43,54	6025	625.08	10,37
18	2635	3432	2180	2981	3163	2911	2686	2855	2324	404.02	14,15	2590	375.68	14,51
19	2727	1319	2990	4281	4682	2222	1008	2747	4277	1384.18	50,39	3512	1081.97	30,81
20	4509	7359	6786	4168	7220	5441	5141	5803	5682	1311.00	22,59	5743	85.96	1,50
21	5790	3298	2960	7792	12884	6451	5683	6408	6028	3324.76	51,88	6218	268.80	4,32
22	5326	7122	2144	5478	3169	2206	8709	4879	4695	2510.24	51,45	4787	130.41	2,72
23	3369	2231	1348	3306	2771	2635	2813	2639	3683	690.25	26,16	3161	738.52	23,36
Mean								5356	4952					
CV											35.17			13.23

Mean, Standard deviation, and co-efficient of variation (CV%) for 1 week monitoring, and the mean SD and CV of the mean 7day step count for weeks 1 and 2 are presented.

Table 3. Differences between week 1 and 2 for SAM3[®] parameters total steps and peak activity including the 95% CI of patients with hematological malignancies

Parameter	Week 1 (sd)	Week 2 (sd)	Mean difference (sd) (95%CI)	p-value
Total Steps / 24h	5355.52 (1928.65)	4952.39 (1641.81) average sd wk 1+2: 1785.23	403.13 (1051.55) (-51.59 / 857.85)	.080
Peak activity index	43.04 (6.70)	42.63 (6.50) average sd wk 1+2: 6.60	0.42 (5.09) (-1.78 / 2.62)	.698
Differences between week 1 and week 2 were calculated by means of a t-test.				

Table 4. Results of the SAM3, differences between patients with hematological malignancies and healthy participants

Parameter		Mean (Sd)	Standard error of mean	Mean difference (95% CI)	p-value
Total steps	Patients	5355.52 (1928.65)	402.15	-1008.58 (-1957.92 / -59.24)	.038
	Healthy subjects	6364.10 (1515.65)	276.15		
Peak activity index	Patients	42.74 (6.53)	1.36	-6.90 (-10.48 / -3.33)	<.001
	Healthy subjects	49.65 (6.34)	1.15		
Mean (sd), standard error of the mean, mean difference (+95%CI) and significance for SAM3 parameters (total steps and peak activity index) between patients and healthy subjects. Differences between patients and healthy subjects were calculated by means of a t-test.					